AGENDA ITEM NO: 6 (a)	SUBJECT: **Assessment of consequences to a range of environmental values of continuing to delay implementation of the HWRRP minimum flows for all consented water users**
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Action required

- Zone committee members gain a good understanding of the technical work done to assess the environmental implications of delaying the implementation of the HWRRP minimum flows for all consented users.

Technical work undertaken
Simulated flow records for the Hurunui River and Waiau River have been created based on all consents tied to the minimum flows in the Hurunui Waiau Rivers Regional Plan (HWRRP).

These simulated records have been compared with the observed flows in the Waiau River from 2007 and in the Hurunui River from 2010 to now.

Information available from the HWRRP hearing evidence has been used to assess the difference between the observed flows and the simulated flows (with all consents tied to HWRRP minimum flows) to assess the consequences on a range of environmental values. No new technical investigations have been done.

The simulated flows, and hence the assessment, does not take into account any changes that may occur with the piping of the AIC irrigation scheme.

Summary of results
Continuing to delay implementing the HWRRP minimum flows for all consented users has the following environmental implications:

i. Potentially significant negative implications for salmon migration in both rivers but particularly in the Waiau River;

ii. Slightly negative implications for:
   - The risk of potential mouth closure in both rivers, but more so in the Waiau River
   - Jetboat passage in both rivers
   - Riverbed bird nesting and feeding in the Hurunui River

iii. Negligible effect on:
   - Nuisance periphyton growth
   - Riverbed bird nesting and feeding in the Waiau River.

iv. No effect on sediment transport and geomorphology or on groundwater quality.

Background and purpose

The Hurunui-Waiau Zone Committee requested technical work to inform them on the implications of continuing to delay implementation of the HWRRP minimum flows for all users. The Committee requested the technical work be developed collaboratively with the Science Stakeholders Group (SSG). A list of work items was developed with the SSG at a workshop on the 21 June 2017. Since then Environment Canterbury staff have been working with some of the SSG participants to deliver that work. The work helps inform on the following 4 questions:

1. What are the new HWRRP minimum flows compared to historic consent minimum flows?

2. What proportion of current consents are already on the HWRRP minimum flows?

3. What are the environmental implications of continuing to delay implementing the HWRRP minimum flows for all consented users?

4. What are the costs, for irrigators who are not already on the HWRRP minimum flows, of moving to those minimum flows?

This paper will directly address questions 1 to 3. An initial estimate to answer question 4 is provided in the next agenda paper by Andrew Barton, AIC.

Other information relevant to this subject requested by the Committee and/or the SSG includes:

- Ideas for other actions to improve water quality and/or biodiversity?

- Commentary on the latest advances in research to inform flow setting in New Zealand?

The first item has already been addressed in invited presentations to the Committee by Andrew Barton of Amuri Irrigation Company (17 July 2017) and Scott Pearson of Fish and Game (21 August 2017). The second item will be addressed in a separate paper to the Committee.

Question 1: What are the new HWRRP minimum flows compared to historic consent minimum flows?

Figure 1 shows the Waiau River at Marble Point historic A Block minimum flows together with the HWRRP minimum flows. February and March see higher minimum flows from 15 m^3/s (historic) to 20 m^3/s (HWRRP), while for the remainder of the year the minimum flows are lower, from 25 m^3/s to 20 m^3/s.

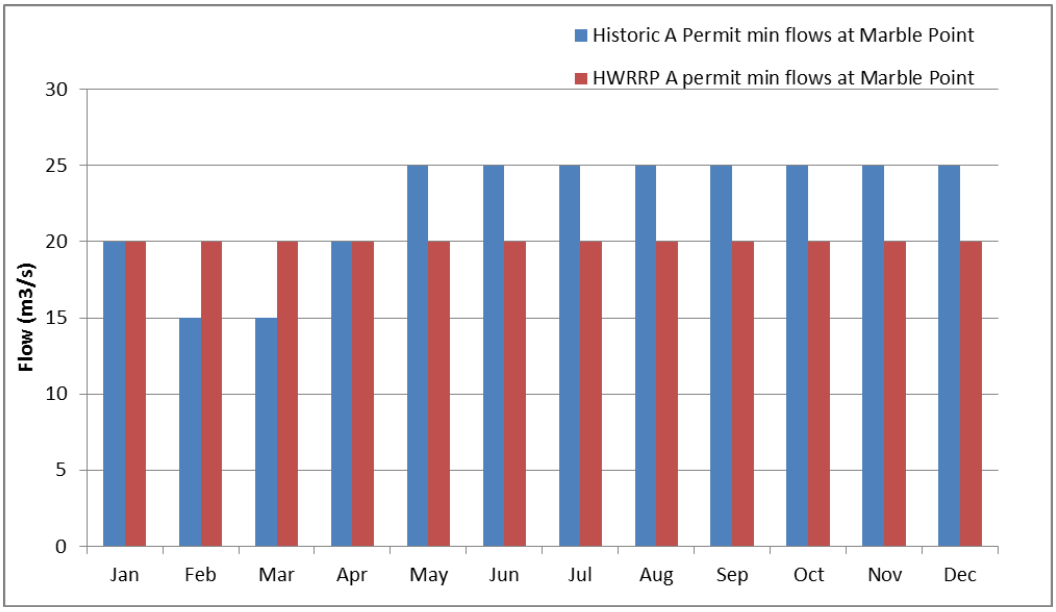

Figure 1: Historic and HWRRP minimum flows for the Waiau River at Marble Point

Figure 2 shows the historic minimum flows along with the HWRRP minimum flows for the Hurunui River at Mandamus. Amuri Irrigation Company (AIC) has historically had a slightly higher minimum flow than the remainder of A Block consents. The HWRRP sees December to April with higher minimum flows than historically.

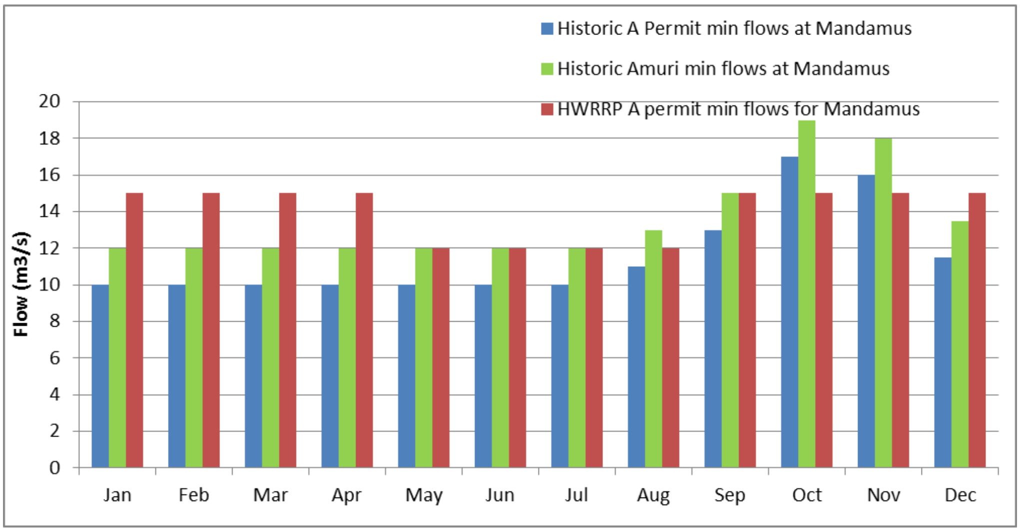

Figure 2: Historic and HWRRP minimum flows for the Hurunui River at Mandamus

Question 2: What proportion of current consents are already on the HWRRP minimum flows?

Environment Canterbury consents records show that:

For the Waiau River catchment:

- Approximately 6 m^3/s of A Block allocation (29 consents) currently have conditions requiring the HWRRP minimum flows, out of approximately 17 m^3/s (66 consents) – Waiau River main stem A Allocation Block only.

- Of the 37 consents not yet attached to HWRRP minimum flows there are 22 consents that are due to expire by the end of 2020 and so will be given conditions requiring to meet HWRRP minimum flows if and when they are renewed.

For the Hurunui River catchment:

- Approximately 300 L/s of A Block allocation (5 consents) currently have conditions requiring the HWRRP minimum flows, out of a catchment total allocation of approximately 7.5 m^3/s (40 consents)- Hurunui River main stem A Allocation Block only.

- Of the 35 of consents not yet attached to HWRRP minimum flows there are 21 consents that are due to expire by the end of 2020 and so will be given conditions requiring to meet HWRRP minimum flows if and when they are renewed.

Please note: These figures are estimates based on a basic inventory of the live lowflow database and refer to main stem allocation only. Final reviewed Consent Inventory figures were not available for this paper, but the figures quoted here will be updated when available.

Question 3: What are the environmental implications of continuing to delay implementing the HWRRP minimum flows for all consented users?

General approach

Peter Brown (AIC) set up a model estimating what the flow regime would have looked like in both rivers if all users had been operating according to the new HWRRP minimum flows, and compared that to the existing situation where some users are still operating on historic minimum flows. We then used evidence from the HWRRP hearing and other literature sources to assess what the differences between these two flow regimes meant for various identified environmental values over the years, and what this might mean going forward.

In other words, we assessed what the river environment has missed out on since the HWRRP became operative in December 2013 as a result of not having yet moved everyone to the HWRRP minimum flows, and then also the environmental risks of continuing to delay moving all consents to the new minimum flows.

Brief Methods

1. Peter Brown (AIC) used a model to produce simulated flow records for the Hurunui River at SH1 and the Waiau River at the Mouth, assuming all consents are tied to the HWRRP minimum flows. The model does not represent flows as a result of the Amuri Irrigation's piping project. For each of the rivers two scenarios were modelled: Scenario 1 takes into account demand and supply, whereas Scenario 2 assumes water is taken when available. Further details on the approach used and results are described in Peter Brown's memo, which has been made available to you electronically.

2. We have reviewed Peter Brown's method and resulting model and consider it fit for purpose in assessing the effect on river flows of changing to HWRRP minimum for all consented water use. In addition to the statistics produced by Peter Brown we used the time series for Scenario 2, most conservative approach, described above to produce comparisons of various flow statistics, hydrographs and flow duration curves relevant to assessing environmental effects. For the Hurunui River at SH1 we used data from the water year 2007 (1 July 2007 to 30 June 2008) to date and for the Waiau River at the Mouth we used data from 2010 to date. This because the Hurunui River at SH1 water level recorder data was only rated for high flows for various periods of time prior to 2007. Data for the reinstated water level recorder in the Waiau River at the Mouth is available from February 2010.

3. We then used the flow descriptions provided above in combination with information available from hearing evidence to assess the difference between the scenarios for several aspects of environmental values including:
    - Fish habitat and migration
    - Mouth closure potential
    - Nuisance periphyton growth
    - Jet boating
    - Riverbed bird nesting and feeding

Results and conclusions

Fish habitat and migration

1. Salmon Migration

The hearing commissioners report (Salmon et al. 2013) indicated that they considered flows of 15 m^3/s and 20 m^3/s in the Hurunui and Waiau Rivers respectively were likely to provide for salmon passage. The evidence provided generally focussed on providing a minimum water depth of 25cm to allow salmon to negotiate their way upstream. The upstream migration period for chinook salmon in the Hurunui and Waiau Rivers is from January to April (Jellyman 2012). The analysis carried out considered the total and consecutive number of days below the flow required to provide for salmon passage for these months.

The observed flows in the Hurunui River at SH1 fell below 15 m^3/s in only 1 out of seven years (from 2010 to 2016). The HWRRP minimum flow and allocation regime would have reduced the number of days the flow went below 15 m^3/s that year from 15 to 6 (Table 1). The maximum consecutive number of days would have reduced from 9 to 4.

The observed flows in the Waiau River at the Mouth fell below 20 m^3/s in 4 out of the seven years assessed. The HWRRP flow and allocation plan rules would have reduced that to 2 out of seven years. The HWRRP plan rules would have also reduced the total and consecutive number of days the flow was below 20 m^3/s (Table 2). In the 2014 water year for example, the total number of days flows were below 20 m^3/s from January to April would have reduced from 53 to 21, and the maximum consecutive number of days would have reduced from 22 to 9. Salmon generally move reasonably quickly from the river mouth upstream (over days to weeks), as opposed to other species which may take much longer. It is undesirable for them to delay upstream migration for long periods while waiting for flows to increase. The implications of the current flow regime compared to the HWRRP flow regime on the migration of salmon in the Waiau River are therefore potentially reasonably large.

<u>Conclusion</u>

Salmon migration in the Hurunui River is likely to be impacted by the current flow regime only in very dry years. The effect of the current flow regime on salmon migration in the Waiau River is greater than would be the case under the HWRRP flow regime, because the lower minimum flows lead to greater frequency and duration of flows that are below levels likely to provide for salmon migration.

Table 1. Total and maximum consecutive days with flows below 15 m^3/s between January and April in the Hurunui River at SH1.

Year	Days below 15m^3/s (observed/with historic minimum flows)	Days below 15m^3/s (modelled/with HWRRP minimum flows)	Maximum number of consecutive days below 15m^3/s (observed/with historic minimum flows)	Maximum number of consecutive days below 15m^3/s (modelled/with HWRRP minimum flows)
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	15	6	9	4
2015	0	0	0	0
2016	0	0	0	0

Table 2. Total and maximum consecutive days with flows below 20 m^3/s between January and April in the Waiau River at the Mouth.

Year	Days below $20m^3/s$ (observed/with historic minimum flows)	Days below $20m^3/s$ (modelled/with HWRRP minimum flows)	Maximum number of consecutive days below $20m^3/s$ (observed/with historic minimum flows)	Maximum number of consecutive days below $20m^3/s$ (modelled/with HWRRP minimum flows)
2010	0	0	0	0
2011	0	0	0	0
2012	20	0	18	0
2013	5	0	3	0
2014	53	21	22	9
2015	8	0	5	0
2016	0	0	0	0

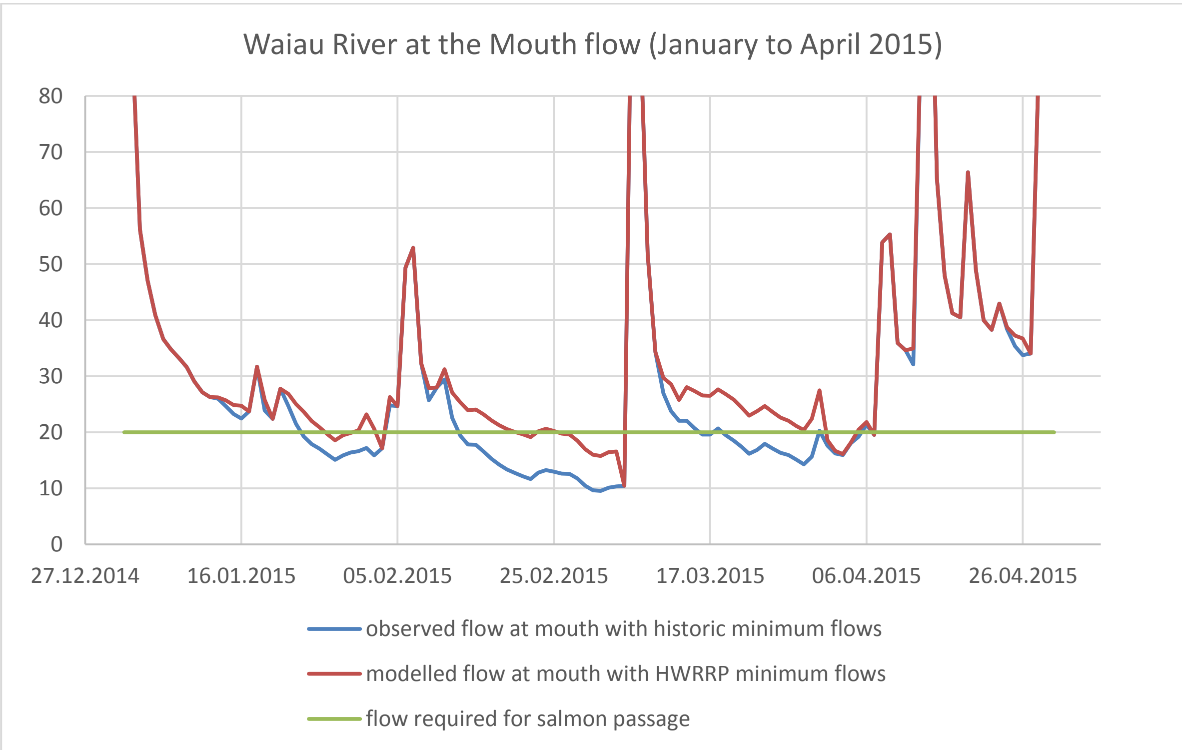

Figure 3: Flows in the Waiau River at the Mouth for January to April compared to flows required for salmon passage.

2. Weighted usable area (WUA) for different aquatic species.

Weighted usable area is the capacity of a river to provide suitable habitat, food, and other requirements for a particular species at a particular life stage. The assessment approach here has been to consider the flow range that flows are reduced by the current flow and allocation regime compared to the HWRRP regime, and combined with the WUA vs flow curves available, to determine whether the amount of habitat for a particular species or value is likely to increase or decrease under the HWRRP regime. Evidence related to weighted usable area for a range of species was presented during the HWRRP hearing process (Duncan 2012, Jowett 2012), and this work built on earlier habitat suitability studies carried out in both the Hurunui and Waiau River catchments (Duncan and Shanker 2004, Duncan and Bind 2009). While we did not have access to the electronic versions of the WUA vs flow curves that would be needed to accurately quantify the predicted changes, we were able to use the information provided in hearing evidence to estimate approximate changes

Duncan and Shankar (2004) produced WUA curves for a number of species in the Hurunui River. This work indicates little change in habitat for juvenile salmon (52-102mm), but an increase in habitat for salmon fry (<55mm), salmon holding water and more area suitable for salmon angling under the HWRRP regime. Torrentfish habitat is likely to reduce slightly, as is adult brown trout habitat. The amount of young trout (yearling) habitat is likely to remain the same under the HWRRP rules compared to the current situation. The amount of habitat for both large and small longfin and shortfin eels is likely to increase under the HWRRP rules. Invertebrate food production is likely to decrease, and habitat for the mayfly *Deleatidium* is likely to increase slightly.

For the Waiau River, WUA curves were produced by both Duncan and Bind (2009), and Jowett (2012). These two studies covered different, but overlapping, parts of the Waiau River. Both studies predict an increase in habitat for small longfin eels with increasing flows, but Jowett predicted a slight reduction in habitat for large longfin eels. Shortfin eel habitat is likely to increase for both small and large individuals. This conflicted with the predictions of Duncan and Bind who predicted a slight increase in habitat over the range of affected flows. Both studies predicted increases in torrentfish habitat with increases in flow. *Deleatidium* and other invertebrate "food" species are likely to have more suitable habitat under increased flows, as are salmon at all life stages. Trout habitat predictions are less clear, with conflicting predictions from the two studies. However, both studies predicted reasonably small changes in available habitat over the flow ranges of concern.

Conclusion

Habitat availability in the Hurunui River will increase with a change to the HWRRP minimum flows for most salmon life stages and eels, reduce for torrentfish, adult trout and invertebrate food, and remain about the same as current levels for juvenile salmon and juvenile trout. Habitat availability for most species is likely to increase in the Waiau River with a change to the HWRRP minimum flows.

Table 3. Summary of weighted usable area changes predicted if the HWRRP minimum flow and allocation regime is implemented. (+ increase in habitat, - reduction in habitat, +/- minimal or no change likely, ? effects uncertain)

	Salmon fry	Juvenile salmon	Salmon angling	Salmon holding	Torrentfish	Juvenile trout	Adult trout	Small long fin eels	Large longfin eels	Small shortfin eels	Large shortfin eels	Deleatidium	Invertebrate food	Black fronted tern	Wrybill
Hurunui River	+	+/-	+	+	-	+/-	-	+	+	+	+	+	-	+	+
Waiau River	+	+	+	+	+	?	?	+	?	+	+	+	+	+	+

Mouth closure potential

Evidence presented during the hearing indicated that flows of 15 m^3/s or greater were required to maintain an open mouth in both the Hurunui and Waiau River (Hicks 2012). Both modelled and observed flows were above 15 m^3/s in both the Hurunui and Waiau Rivers from August to November, over the 2010 to 2016 water years. Most inward movement of fish takes place during these months, and it is important that the mouth is open during these months to allow for recruitment of migratory species. (Jellyman 2012).

An assessment of flows outside of these months indicated the current flow regime is likely to have little impact on mouth closures, except during very dry years. In early 2015 for example, the flows in the Hurunui River at SH1 dropped below 15 m^3/s several times because of the current flow regime, for one or two days at a time (Figure 4). Flows in the Waiau River at the Mouth fell below the 15 m^3/s threshold for approximately seventeen consecutive days over the same period because of the current flow regime (Figure 5). The HWRRP minimum flows would have prevented this occurring save for one day. During this time (January to February), Chinook salmon and common bullies are attempting to migrate from the sea into the rivers (Jellyman 2102).

In February and March 2015 flows in the Waiau River were particularly low, with Marble Point recording the fourth lowest Annual Low Flow (ALF) in 49 years and flows at the Mouth were by far the lowest recorded ALF, of 10.3 m^3/s, (36 years of record). It has been reported by some community members that the mouth was closed for short periods about this time, although this is anecdotal only. There are a few other occasions when local landowners recall the mouth has been closed, however no dates/times could be given. Access to the Waiau River mouth is limited to farm tracks so not visited nor reported by the general public.

Low flow conditions play a significant role when considering river mouth stability and closure. Changing the minimum flow from 15 m^3/s to 20 m^3/s for the Waiau River at Marble Point in February and March, when flows are generally lowest, for all consented abstractions would reduce the risk of a potential mouth closure, as there is uncertainty and risk around the assumption that 15 m^3/s of river flow at Marble Point would be sufficient to maintain an open river mouth. This relies on the flow relationship between the Waiau River at Marble Point and the Waiau River at the Mouth, but also on water use, tributary contribution, compliance with the restriction regime and climate and wave conditions.

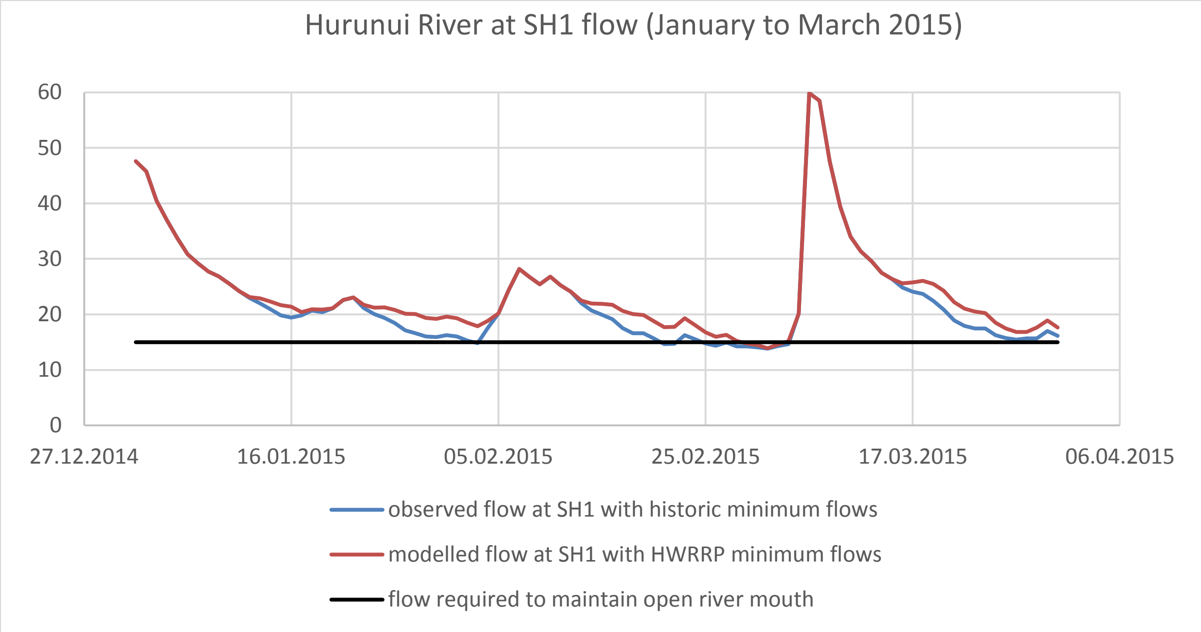

Figure 4: Observed and modelled flows for the Hurunui River at SH1 from January to March 2015. The black line is the flow required to maintain an open river mouth.

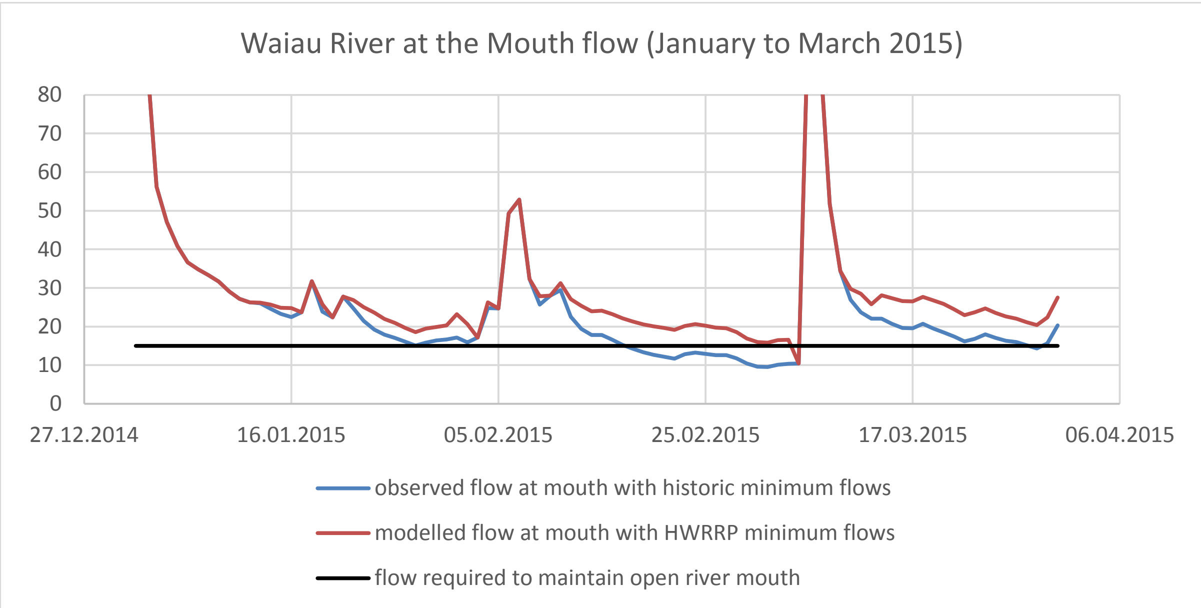

Figure 5: Observed and modelled flows at the Waiau River mouth from January to March 2015. The black line is the flow required to maintain an open river mouth.

<u>Conclusion</u>

The current flow regime is unlikely to impact mouth opening from August to November in both the Waiau and Hurunui Rivers. This period is considered critical for inward fish movement. The flow regime is likely to impact mouth opening in other months of the year only infrequently during very dry periods in some years.

Nuisance periphyton growth

Flushing flow events two and three times the size of the median flow have been identified as important factors related to nuisance periphyton growth (Snelder 2012). The frequency of these flushing flow events influences the magnitude, frequency and duration of nuisance benthic periphyton blooms. The analysis carried out found no difference in the frequency of Fre2 or Fre3 events in the Hurunui or Waiau Rivers under the current flow regime compared to the HWRRP flow regime (Tables 4 and 5), as was expected because differences in minimum flow rules typically don't affect flushing flows.

Table 4: Frequency of Fre2 and Fre3 flushing events in the Hurunui River at SH1 between 2007 and 2016

Year	Observed Fre2 events (with historic minimum flows)	Modelled Fre2 events (with HWRRP minimum flows)	Observed Fre3 events (with historic minimum flows)	Modelled Fre3 events (with HWRRP minimum flows)
2007	4	4	2	2
2008	11	11	8	8
2009	8	8	6	6
2010	9	9	7	7
2011	9	9	4	4
2012	8	8	8	8
2013	11	11	9	9
2014	6	6	5	5
2015	5	5	4	4
2016	9	9	6	6

Table 5: Frequency of Fre2 and Fre3 flushing events in the Waiau River at the Mouth between 2010 and 2016

Year	Observed Fre2 events (with historic minimum flows)	Modelled Fre2 events (with HWRRP minimum flows)	Observed Fre3 events (with historic minimum flows)	Modelled Fre3 events (with HWRRP minimum flows)
2010	9	9	11	11
2011	9	9	6	6
2012	11	11	10	10
2013	11	11	12	12
2014	8	8	6	6
2015	9	9	6	6
2016	10	10	8	8

The other mechanisms by which flow can influence periphyton biomass are sheer stress and temperature. Previous work by Duncan (2007) in the Hurunui River indicates that the HWRRP flow regime is likely to increase the habitat available for diatomaceous algal growths, and decrease the habitat available for long and short filamentous algae. Filamentous algal growths have the potential to smother aquatic habitat, and may reach nuisance levels under suitable conditions. Diatomaceous growths tend not to cause ecologically deleterious effects, and generally provide food for benthic invertebrates (Duncan 2007).

Duncan and Bind (2004) and Jowett (2012) both produced weighted usable area curves for periphyton growth in the Waiau River. Duncan and Bind predicted small increases in long filamentous algae habitat with increasing flows, contrary to predictions by Jowett, which predicted reasonably large reductions in habitat for this algae type. Inundation of small side braids and the potential for low water velocities which favour the development of filamentous algae, is the likely reason behind the findings of Duncan and Bind. Velocities in the main channels are likely to become less favourable for this potentially nuisance algae with increasing flows. Both studies predicted small increases in short filamentous algae habitat, and reasonably large increases in habitat suitable for diatomaceous algal growths.

It is also possible that increased water temperatures due to lower flows (Cox and Rutherford 2000) will result in increased algal growth (Matheson *et al.,* 2012a). Empirical relationships between algal growth and water temperature have not been developed, and it is therefore difficult to quantify the potential change in periphyton biomass.

Conclusion

There is unlikely to be a change in flushing flow frequency for either the Waiau or Hurunui Rivers under the new HWRRP minimum flows. Habitat suitability modelling indicates increased water velocities resulting from higher flows are likely to reduce the amount of habitat suitable for filamentous algae in the main stem for both the Hurunui and Waiau Rivers. Habitat for thin diatomaceous algae, generally considered to be suitable for invertebrate grazing, is likely to increase.

Jet boating

Submitters proposed a range of flows suitable for jet boating in the Hurunui River, and these included 10 m^3/s (Duncan 2012), 20 m^3/s (Jowett), up to 35 m^3/s or even 45 m^3/s (Rob Gerard) for some sections of the river. Flows did not drop below 10 m^3/s between 2007 and 2016. The AIC abstraction is unlikely to have a significant impact on the frequency of flows above 35 m^3/s or 45 m^3/s. However, when considering the 20 m^3/s flow recommendation for jet boating, the current flow and allocation plan is likely to have more impact. Flow duration curves for water years between 2010 and 2016 indicate the current flow regime is likely to increase the frequency that flows are below 20 m^3/s by between approximately 2 and 5 percent.

Flows proposed for the Waiau River to allow jet boat passage were 15 m^3/s, 25 m^3/s (Duncan 2012) and 30 m^3/s (Jowett 2012). Flows have only fallen below 15 m^3/s (at the mouth) very occasionally between 2010 and 2016, the most significant event being a period of seventeen days in early 2015, reaching a low of approximately 9.5 m^3/s. If the HWRRP minimum flows had been implemented, flows would have fallen below 15 m^3/s for just one day. Using the 25 m^3/s and 30 m^3/s flows proposed, flow duration curves for the Waiau River at the Mouth between 2010 and 2016 water years indicate flows would be suitable for jet boating between approximately 2% and 8% more often under the HWRRP flow regime, compared to the current flow regime (Figure 7).

Conclusion

The frequency flows are above the 10 m^3/s and 35 m^3/s thresholds is unlikely to change under the HWRRP flow regime. The river is likely to be above the 20 m^3/s threshold proposed for jet boating more frequently under HWRRP minimum flow rules.

Jet boating in the Waiau River will improve at very low flows (below 15 m^3/s) only very occasionally if the HWRRP minimum flow rules are implemented. Conditions are likely to be above the 25 m^3/s and 30 m^3/s thresholds more frequently if the HWRRP minimum flow rules are implemented.

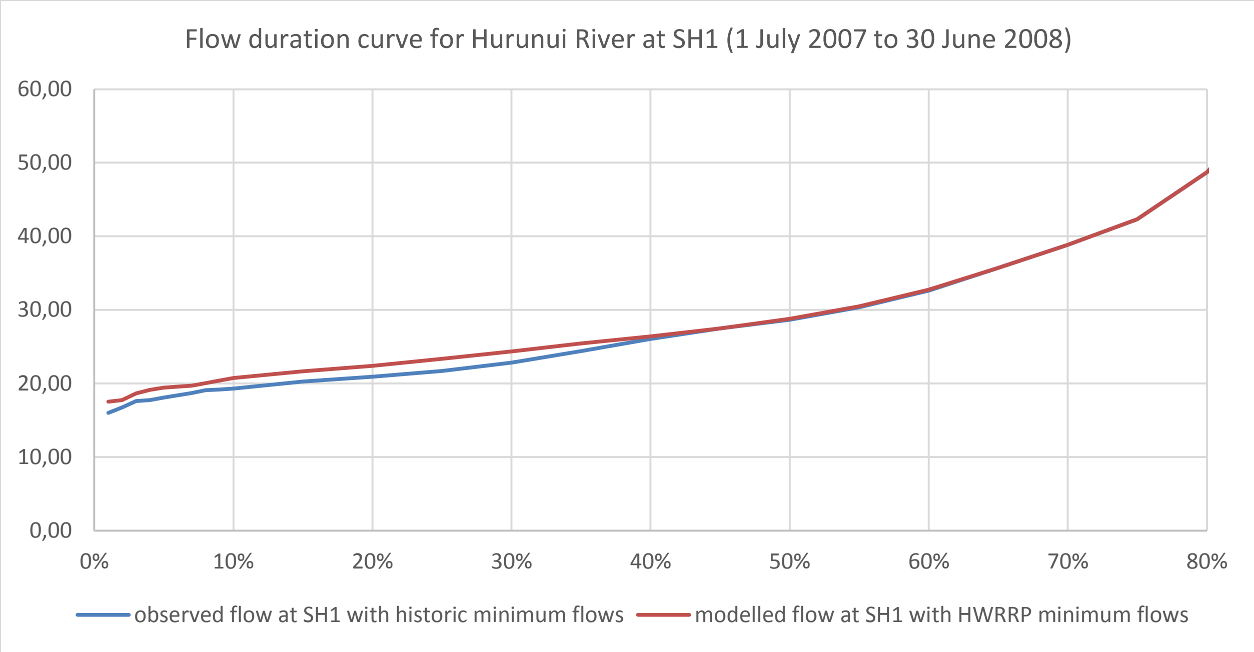

Figure 6: Flow duration curve for the Hurunui River at SH1 for the 2007 water year.

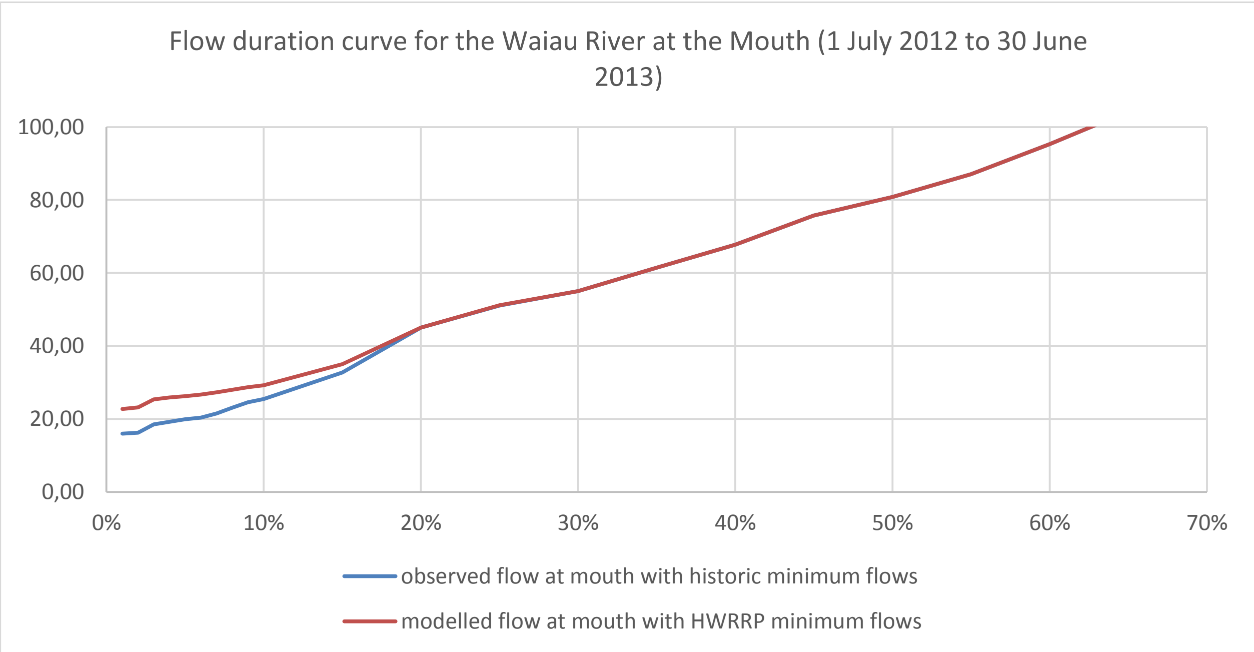

Figure 7: Flow duration curve for the Waiau River at the Mouth for the 2012 water year.

Riverbed bird nesting and feeding

Evidence presented at the hearing indicated flows of 40 m^3/s and 25 m^3/s were optimal to support river bird nesting and feeding respectively, in both the Hurunui and Waiau Rivers. The months of September to December are the peak of the breeding season, and are therefore of most interest in this regard (Hughey 2012).

Analysis of flow duration curves from September to December for the last seven years (2010 to 2016) indicate the current flow regime in the Hurunui River is likely to exacerbate the impacts of low flows on bird feeding and nesting opportunities during the breeding season only in years with reasonably low flows. In 2010 for example, the current flow regime resulted in flows approximately 2 m^3/s less than those modelled under the HWRRP minimum flow rules for 15 consecutive days in

December (Figure 8). Flows during this period were approximately 20 m^3/s. For 5 out of 7 years there is no significant effect of the current regime on the frequency of flows falling below the optimum flows identified by Hughey (2012). For the other two years the current flow regime increased the magnitude but not the duration of flows falling below the optimum flows identified. Using habitat suitability curves generated by Duncan (2012), it is estimated that black fronted tern habitat suitable for feeding on invertebrates would be reduced because of the current flow regime compared to the HWRRP regime. Increases in habitat for wrybill feeding and black-fronted tern habitat suitable for feeding on fish are reasonably small, but still increase as flow increases.

For the Waiau River, there is no notable difference in the observed and modelled HWRRP flow regime during the months of September to December from 2010 to 2016. The hydrograph for this period in 2014 illustrates this clearly (Figure 9). The most significant effects of the current minimum flow and allocation regime are observed outside the breeding season. Flow duration curves for a number of full water years (2010 to 2016) indicate ideal flows for river bird feeding are likely to be available approximately 5% less frequently under the current flow regime than the HWRRP flow regime. Modelling by Duncan and Bind (2009) indicates habitat suitable for black-fronted tern feeding is likely to increase reasonably significantly under the HWRRP minimum flow rules, with only modest habitat increases predicted for wrybill.

<u>Conclusion</u>

Flows during the nesting season (September to December) for the 7 years analysed (2010 to 2016) were slightly lower under the current flow regime relative to the HWRRP flow regime in very dry periods in the Hurunui River. Flows in the Waiau River during this period have been largely unaffected by the current flow regime compared to the HWRRP flow regime. The current flow regime is likely to reduce the area available for feeding for both black-fronted terns, and to a lesser extent wrybill, outside of the breeding season.

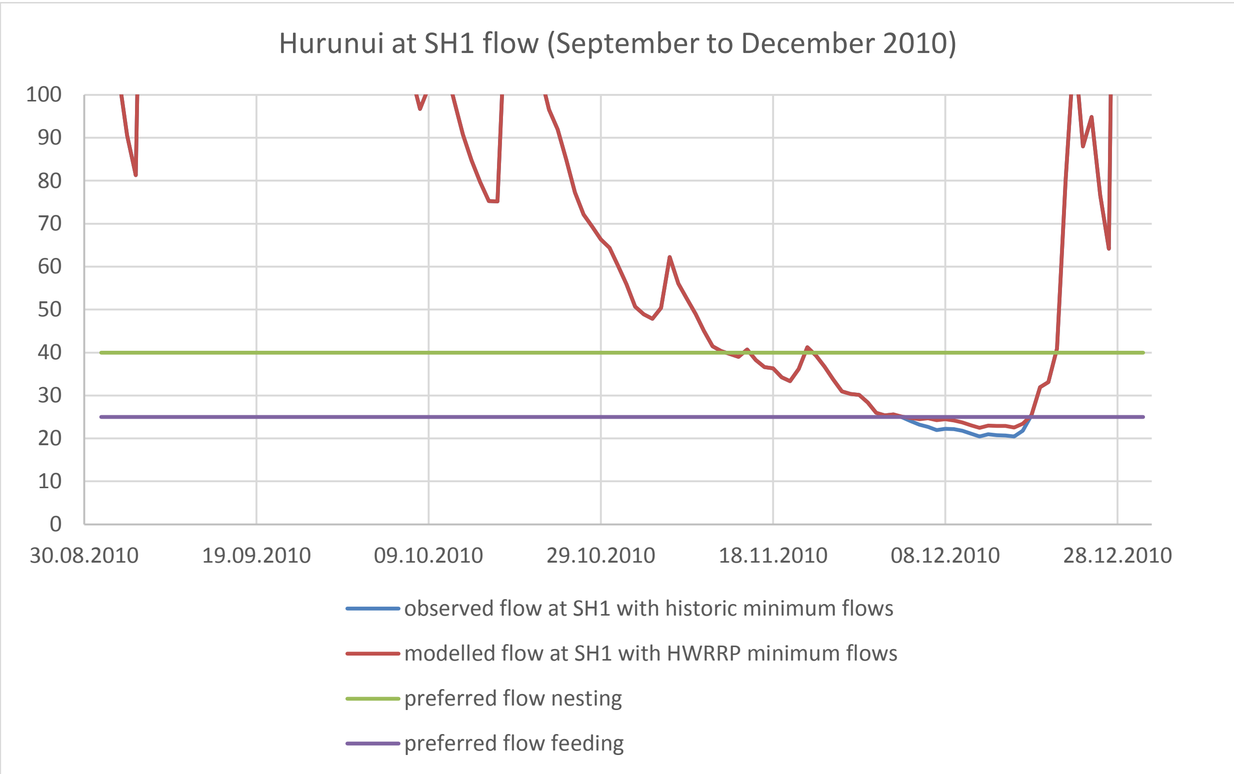

Figure 8. Observed and modelled flows in the Hurunui River at SH1 for September to December 2010 compared to optimum flows for river bird nesting and feeding.

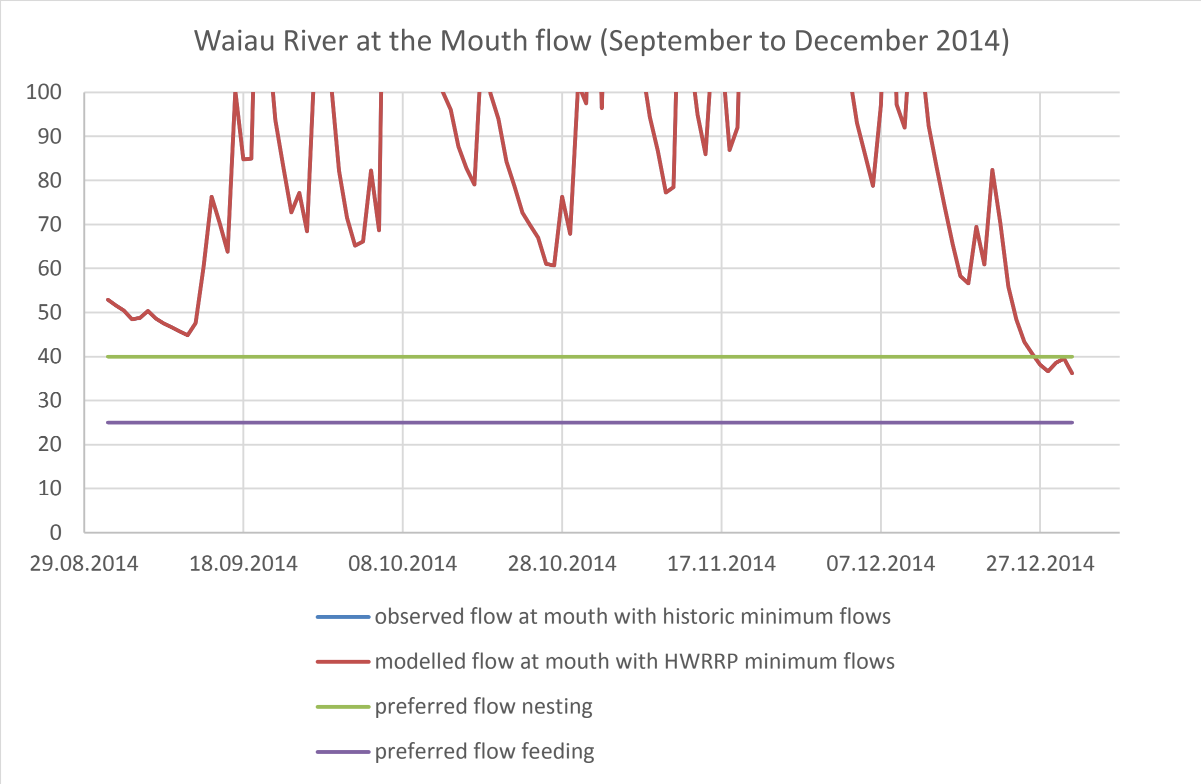

Figure 9. Observed and modelled flows in the Waiau River at the Mouth September to December 2014 compared to optimum flows for river bird nesting and feeding.

Other points for consideration

Amuri Irrigation's piping project

We expect overall return flows to both rivers to decrease and the effects to be greater and more noticeable in the Waiau River based on information from AIC.

Groundwater

Implementing the HWRRP minimum flows is not expected to have a noticeable effect on groundwater quality. This assessment doesn't include the impact of the AIC piping project which is expected to reduce recharge to the groundwater system which will lower groundwater levels and consequently impact groundwater quality.

Sediment Transport and Geomorphology

The effects of further deferring the consent review will be insignificant on these factors as the consent review will affect the minimum flow conditions, whereas the main driver of change in bedload transport, channel maintenance, fine sediment flushing and bed turnover is change in actual water use (Hicks 2012).

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